SOME WINTER OBSERVATIONS OF MUSCID FLIES.*

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If the hibernation of the house-fly (Musca domestica L.) and the other disease disseminators of the same family (Muscidæ) could be prevented, the early spring and summer generations would be controlled. Although these flies are the most common domestic pests the economic importance of a thorough study of their hibernation stages was but recently recognized. It seems that in the past too much had been assumed without actually experimenting to prove the assumption. With the knowledge of several diverging theories in mind, the author began a study of the hibernating stages of Musca domestica L. at College Park, Maryland, 1914–15, under the direction of Prof. E. N. Cory, Maryland State College, and continued, 1916–17, at Columbus, Ohio, under the direction of Prof. Jas. S. Hine, Ohio State University. (Dr. Gary deN. Hough's keys were utilized in determining the species herein discussed).

In order to find out experimentally, how long adults of the house fly would live confined in cages under otherwise natural winter conditions, tests extending throughout the winter were conducted in a large screen insectary and in an unheated stable at College Park, Maryland. The flies which were used in the above experiments were confined in rectangular wire cages (breeding cages—12 x 12 x 24 inches), which had a hole 6 inches in diameter in the upper half of one of the long sides. This opening was protected by a black-cloth sleeve and was used as a convenient method for admitting or replacing adults, food and manure. The adults were fed with fresh milk, which was daily supplied them in small dishes, packed with absorbent cotton. Fresh manure was also placed daily in a small flat dish in each cage as a medium in which eggs might be deposited. When one lot of adults died they were removed and a new lot installed. The new lots of flies were bred out in the greenhouse as will be described elsewhere in this paper.

These experiments show the greatest longevity of the adult to be 44 days (December 12, 1914–January 29, 1915), extreme temperatures 15° –63°, mean 45°, in the unheated stable

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and but 30 days (December 16, 1914–February 2, 1915) extreme temperature 13°–62°, mean 30°, in the insectary. Eggs were not deposited in the insectary until April 20, while in the stable they were noted on May 6th. These trials therefore show that the adults died under modified winter conditions after a short exposure.

These experimental results colaborate those obtained by Dr. F. C. Bishopp (1915), "Notes on Certain Points of Economic Importance in the Biology of the House-fly," who concludes that, "flies which are not kept cold enough to become inactive will either deposit if the temperature is sufficiently high or die comparatively soon." The climatical conditions in Texas are different from those in Maryland and Ohio. This point of varience from Dr. F. C. Bishopp's conditions was well expressed in his remarks that "oviposition was observed to occur on warm days in midwinter at Dallas, Texas, January 14, and at Valde, Texas, on February 5, 1914. Depositions may be expected at these latitudes on mild bright days in winter, especially if these are preceded by a few days of mild weather. During cool weather adults seem to choose places for deposition where the sun is bright and the wind is cut off."

At Columbus, Ohio, several student boarding houses and private houses were examined from roof to basement once a week throughout the winter of 1916–17. A search for flies was also made in the vicinity of the garbage cans of these stations. On December 17, 1916, a total of 7 males and 5 females of Musca domestica L. was collected in the kitchen. Then no adults were observed nor collected until a comparatively warm period about January 10, which brought 1 male and 2 females to the dining room of a private home and on January 28, two males were swept in slow flight from a gas pipe near the ceiling of a kitchen. At the latter station (a boarding club) no extra precautions were taken to screen food products. As a check, however, upon such careless conditions, a private home where every possible precaution was taken, such as screening and covering fly-attractive substances, was examined weekly. The latter station revealed two female Musca domestica on November 5, 1916, as the last collected up to the present writing, April 5th. Musca domestica was observed in flight in a restaurant, March 10, 1916. Therefore from January 28th to March 10th no adult houseflies were observed in dwelling houses.

Sufficient artificial heat and the presence of breeding media, however, will result in different observations. Thus in Columbus, Ohio, Musca domestica was found in all stages, egg, larva, pupa and adult, all winter in the favored environment prevailing in an animal house where the temperature was regulated to 70°. Similar conditions were found in the greenhouse-insectary, where flies were bred from fish, meat and manures. At the Columbus Garbage Disposal Plant these flies were common during the winter, breeding in the thick moist drippings from the vats. In the winter 1914–15, from December 7th to May 21st, the author succeeded in producing 6 generations of houseflies from horse manure in a greenhouse at College Park, Maryland.

Manure piles were also investigated for the immature stages. Significant observations were obtained in Maryland. Large masses of puparia were taken from the north-east corner of a maggot trap containing horse manure on the 2nd and 10th of December, 1914, and on the 13th of January, 1915, then again from the south side of the same pile on the 13th of May, 1915. Some advantageous effect produced by the trap prevented the rearing of adults from these puparia. Probably draining the pile, thus loosening it, retards heating by fermentation, allows abundance of ventilation and the corresponding decrease in temperature of the pile. Furthermore, an examination of the puparia still in the pile in the spring revealed no emptied pupæ shells from normal emergence. The revealing of so many puparia on the manure pile on the trap from very early winter and then throughout the winter apparently indicates that under natural conditions the housefly hibernates as pupæ. At Columbus, however, several scattered batches of eggs were found but these did not hatch when placed in the insectary. Maggots of the housefly were not taken in these situations this winter. Puparia, however, were collected January 6th in guinea-pig manure pile containing rabbit and pig carcasses on west side of Animal House. They were brought into the laboratory where a male Musca domestica L. emerged the next day. A very large mass of puparia was found February 26, 1917, about 2 inches above the surface of the ground and about 2 feet within the southwest edge of a pile of sheep manure. This manure was undisturbed all winter, except for the addition of cleanings from the sheep sheds. This mass of puparia was

placed in a breeding box in the insectary where one male Musca domestica L. emerged March 10th, 1917 (13 days after isolation), another male March 11, 1917 (14 days) and two females on March 12th (15 days). These evidently spent most of the winter in this resting stage. The remaining puparia of this mass revealed a large percentage empty and showing the evidence of emerged parasites. Of 615 housefly puparia (identified by the structures of the posterior stigmal plates as seen under the binocular) 196 were so injured that I could not tell what had emerged from them. Of the more perfect 419 puparia, 385 or 91.8% had small holes characteristic of parasitized pupæ and 34 or 8.1% had the normal T breaks at the anterior end.

Briefly, then the above hibernating experiments and observations with Musca domestica L. may be summarized for Maryland and Ohio as follows:

1. All stages may be obtained in rare conditions of artificial heat and breeding media.

2. Under natural conditions neither eggs nor maggots were found alive in the normally perferred situations, although the maggots will probably be found in early winter.

3. The adults did not live more than 44 days (experimentally) nor were they collected during the winter proper in houses where it was formerly supposed they were hiding.

4. The few samples of puparia taken from their preferred environment in midwinter (February 26th, 1917) at Columbus and then their successful emergence March 10th to 12th under artificially heated conditions, in spite of the large number affected by fall parasites, apparently indicates that under natural conditions the housefly (Musca domestica L.) hibernates as pupæ.

The winter of 1916-17 afforded an unusually good opportunity to study hibernating conditions because the temperature seemed to lower gradually at first and the cold part of the season was not interrupted very frequently by unusual warm periods. However, such interruption did occur about the 6th of January and again on the 26th of February.

Lucilia sericata Meig.

The common greenbottle was collected outside on the 7th of November, 1916, and was not taken again until the 24th of March, 1917.

In the presence of artificial heat and breeding media Lucilia sericata in addition to Musca domestica was collected in all stages in the insectary all winter. On the 25th of February, 1916, two males and one female were placed in a breeding cage (of the type previously described) over some banana and fresh beef. This female deposited 4 masses of eggs before she died—one on the 3rd of March, 1916, containing 163 eggs (by actual count) another on the 6th of March, containing 232 eggs (by actual count) another on the 9th of March, containing 119 eggs (by actual count) and another on the 14th of March, containing 200 eggs by estimate. Thus in early spring a female of unknown age produced 714 eggs within a period of 7 days. A female emerging March 22nd from this first mass of eggs was placed in a cage with 3 of her brothers under conditions similar to that of their parent. On the 7th day after her emergence this female produced her first batch of eggs.

On the 15th of October, 1916, a fish head literally covered with muscid eggs was taken from a garbage can at one of the boarding-house stations and placed in a battery jar over an inch layer of moist sand. In the insectary most of the eggs hatched within 24 hours and shortly afterward, on the 17th of October, the fish head became insufficient, therefore necessitating more food. The maggots became so numerous within the jar, which was covered with a glass plate, that they formed a horizontal layer, standing on their heads, so that on looking down upon the mass one could see a wave of wriggling, crowding, pushing posterior ends. Still more fish was provided for them and when this could not be obtained soon enough, they began feeding upon one another. Many empty skins were found punctured with holes made by the greedy survivors who then proceeded to pump the body fluids from their companions.

Just as soon as these maggots pupated they were placed over moist sand in vials (1 inch in diameter by 3 inches tall) and covered with a tight cotton plug. These vials were placed in a rack about 10 inches from a south window (shaded from southwest by the front of the building) of the laboratory where the room temperature averaged 70° all winter. Most of the maggots pupated 15 days after hatching. Others appearing to be in a pre-pupal stage were placed in vials November 1st. Of this latter lot, some pupated in 64 days, others 81 days and still some in 101 days after hatching. The pupal period

of these persisting maggots was 27; 4–?, 15 and 16 days respectively, thereby completing the developmental or immature stage as follows:

One male on 11th November, 1916—27 days; one female 16th of November—32 days; one male on 15th January, 1917—92 days; one female 9th of February—117 days; one male on 10th of February—118 days.

The variation of from 17 to 101 days in the maggot stage, and this under conditions which ordinarily hastens their development is particularly noteworthy.

Maggots of this species were taken November 10, 1916, from the sheep manure pile, previously described. These pupated in vials 3 days later and were placed in the laboratory where they remained until February 28th, 1917, where 1 male appeared after resting in puparia 107 days.

Maggots were again taken from this same manure pile on January 6th, 1917. These pupated in vials in the laboratory 11, 17 and 19 days later and brought forth adults in 11, 15 and 16 days respectively—these emerging from January 28th to February 10th.

Some of the sheep manure taken January 6th was placed in a breeding box in the cool chamber of the insectary. This chamber became very hot, however, on sunny days. Adults appeared in this box from 49 to 64 days after, thus emerging from the 24th of February to the 10th of March.

Lucilia sericata Meig. was also bred from maggots found on a dead sparrow in the autumn, from decaying cantaloupe and from guinea-pig manure.

The above data points to the larval and pupal stages as the hibernating condition for Lucilia sericata Meig.

Lucilia caesar L.

This species does not seem to be as common in the vicinity of Columbus as does the sericata. Maggots, however, were taken on the 27th of October, from the guinea-pig manure pile, containing carcasses. One pupated in a vial in the laboratory on the 10th of March (135 days after its removal from its habitat). The male emerging 10 days afterward or on March 20, 1917. This remarkable period of more than one-third of a year in the immature stages of this fly is comparable with that of the L. sericata just described.

Maggots of L. caesar were again taken from guinea-pig manure on January 6, 1917, producing adults from 20 to 32 days later. From this it is suggested that L. caesar may spend the winter in the larval stage.

Lucilia sylvarum Meig.

This species seems to occur still less frequently than the others. A maggot of this form, however, was taken from the guinea-pig manure pile containing carcasses on the 27th of October and was placed in a vial in the laboratory where it pupated 88 days later. The male emerged 33 days after this, thereby requiring a developmental period of more than 121 days.

Phormia regina Meig.

The king of blowflies was taken on the 12th of November, 1916, near a garbage can at one of the stations and was not collected again until the 24th of March, 1917, when it was trapped with meat bait.

Among the masses of eggs taken October 15th, 1915, on the fish head described with Lucilia sericata there were also eggs of Phormia regina. Pre-pupal maggots were transferred from the battery jar in which they were fed, to the breeding vials in the laboratory where they pupated in 15 to 45 days after hatching. The pupal period was brief, extending from 2 to 7 days, adults issuing from November 7th, 1916 (23 days from egg) to December 8, 1916 (54 days from egg). Some of these fresh adults were placed over banana and fish in a breeding cage in the insectary. No eggs were produced. Four males and three females emerged and were immediately transferred to the cages on the 5th of December. In four days 1 male and 1 female were found dead, in five days another pair and still another pair in six days. The remaining male died in eleven days, or December 16, 1916.

A similar longevity test was made with 3 males and 6 females emerging on the 7th of December. One female died in 2 days, another in 3 days, a pair in 4 days, 1 male and 3 females in 5 days and the remaining male on the 10th day.

A peculiar phenomena in the manner of emergence was observed at this time. Similar conditions, however, were observed when working with puparia of Musca domestica, Lucilia sericata and Sarcophaga sarraceniæ. Apparently an

insect became reversed in some way, so that when the anterior end of the puparum was pushed off the apex of the abdomen was revealed instead of the head. These flies invariably died in this condition. Although only a small number behaved in this way, it may have some significance in nature.

As for the hibernation of this species the dates of collection give partial evidence in favor of the immature stages.

Calliphora erythrocephala Meig.

The large bluebottle was taken in the insectary until the 8th of December, 1916, collected outside on the south and west walls of the animal house during a brief warm period on the 6th of January and again in a meat trap on the 31st of March. Among those taken on the 6th of January there was one whose wings were not quite entirely expanded and its ptilinum still extended. On the 8th of December, 1916, eggs of this species were taken in the insectary from the cloth sleeve of a breeding box containing fish. These hatched the next day after their transfer to the fish, December 9th. Adults emerged in the insectary from 26 to 28 days (Jan. 5, 1917) later.

A puparium taken on the 6th of January, 1917, from the guinea pig manure pile containing carcasses was transferred to a breeding vial in the laboratory where a female emerged in 38 days (Feb. 13, 1917).

A maggot taken on the 6th of January from wet earth 2 inches deep and 1½ feet southwest of the sheep manure pile produced an adult female in 24 days (February 24, 1917).

The adult distribution and the occurrence of the living maggots and puparia indicate the immature stages as the hibernating forms.

Calliphora vomitoria. L.

This bluebottle was not found as adult in early winter, but was collected in a meat trap on the 31st of March, 1917. On January 31st, 1917, in the earth 1½ feet southwest of sheep manure pile a maggot of this species was taken, then placed in a breeding vial in the laboratory where an adult female emerged on the 24th of February.

As for hibernation then this species resembles the Calliphora previously noted.

Calliphora viridescens Desv.

This species was not found in the late autumn, but freshly emerged specimens were taken in a meat trap on the 26th of March.

Cynomyia cadaverina Desv.

This was among the first flies to appear this spring. It was taken in the insectary on the 25th of February and outside on the 20th of March, over decaying rabbit. The latest autumn occurrence for this species in Columbus was on the 13th of November, 1916.

Maggots taken on the 31st of January, 1917, from the earth 1½ feet from sheep manure pile were transferred to breeding vials in the laboratory, where they pupated 4 days later (February 4th) and an adult female issued from these on the 24th of February.

The immature stage again seems to be the hibernating condition.

Among the muscids collected early this spring and indicating fresh emergence, as indicated by their clean, perfect condition and comparatively soft chitin are *Muscina stabulans* Fall (March 20th), *Pseudopyrellia cornicina* Fabr. (March 24) and *Pollenia rudis* Fabr.

Pollenia rudis Fabr.

The cluster fly was found occurring as adults every now and then throughout the winter. About 55 were taken December 4th, 1916, in the lock round-house at the Columbus Sewage Disposal Plant. These flies were transferred alive to a breeding cage in the cool chamber of the insectary. During sunny days this chamber recorded from over 100 at noon to about 20 at night. In the extreme temperatures thus provided, they were quite active during sunlight, while toward evening they gradually closed in towards a protected corner of the cage, where they clustered until the sunshine warmed the atmosphere again. They were given banana as food and a layer of wet clay for possible oviposition. As soon as the females died their ovaries were examined for the condition of development. These ovaries were immature, almost negligible until the last female died on the 7th of March. Here the ova were about the size of a normal egg of Musca domestica. All the ova in this fly appeared to be about the same size. The longevity ranged to more than 94 days.

Cluster flies were also collected outside on the 8th and 17th of December, in the old biology building on the 10th of January, in a bath room January 19th, and again at the Columbus Sewage Disposal Plant, March 3, 1917. They were collected quite abundantly outside during a warm period on March 20th. These early specimens, however, appeared to be freshly emerged for their thoraces glistened with the full supply of golden hairs. In older specimens these become broken so that only a small bunch of them remain on the pleura.

Some of these cluster flies caught in traps March 21st and others swept from the west wall of the Domestic Science Building, were placed in a breeding cage over banana and a layer of wet clay, a method previously used by Hutchison. Single eggs were found scattered on the clay on March 24th, but these did not hatch. They were placed in petri dishes on a moistened strip of blotting paper where they were enclosed with a living green earthworm (*Allolobophora chlorotica*), which has been reported as its host. The angleworm was found in the truck garden near the surface in spring and summer, but often 2 to 3 feet under the surface in winter. These worms were brought in from the garden occasionally in the winter and examined under the binocular, but no parasites were observed.

On the 31st of October, 1916, puparia of Pollenia rudis were taken in the truck garden at a depth of 2 to 6 inches. These were placed in breeding vials in the laboratory where one female emerged on the 1st and a male on the 11th of November.

There is plenty of evidence that Pollenia rudis hibernates as adult, although the apparent appearance of fresh spring specimens suggests that it hibernates in the immature stages also.

CONCLUSION.

It has been recommended repeatedly that the adults of flies be killed in early spring in order to reduce the numbers of later generations, but from the evidence brought forth by these winter observations on various Muscids, the maggots and puparia should also receive attention. If manure piles, rubbish heaps and the like, where larvæ and pupæ may winter successfully, are given proper attention during late fall and winter, the immature stages of these flies would be more exposed to fatal temperatures and their numbers thereby reduced.